

CONTENTS

| | | | |
|---|------|---|----|
| Publisher's Foreword | viii | Chapter 4: STANDARDS | |
| Preface | ix | | |
| Chapter 1: INTRODUCTION | | General Features | 30 |
| Goals and Objectives | 1 | History and Organization | 30 |
| Overview | 1 | Nuclear Standards | 31 |
| General References | 2 | International Standards | 32 |
| Exercises | 2 | Nuclear Criticality Safety Standards | 33 |
| Chapter 2: FUNDAMENTALS | | The General Criticality Safety Standard | 34 |
| Overview | 3 | Basic Philosophy | 34 |
| Definitions | 3 | Administrative Practices | 35 |
| Scope | 4 | Double-Contingency Principle | 35 |
| History | 5 | Geometry Control | 35 |
| Principles of Safety | 5 | Control by Neutron Absorbers | 35 |
| Review of Reactor Theory | 7 | Subcritical Limits | 36 |
| Criticality Indices and Correlations | 7 | Safety Margins | 36 |
| Neutron Balance Controls | 8 | Additional Guidance | 36 |
| Criticality Example | 10 | Specialized Standards | 37 |
| Reactor Kinetics | 11 | Standards Needs | 38 |
| Nuclear Fuel Cycle Concerns | 12 | Guides and Manuals | 40 |
| Exercises | 13 | Exercises | 40 |
| Chapter 3: CRITICALITY ACCIDENTS | | Chapter 5: EXPERIMENTS | |
| Accident Experience | 17 | Methods | 43 |
| Process Criticality Accidents | 18 | Critical Facilities | 43 |
| Y-12 Plant | 18 | Critical Experiments | 44 |
| Los Alamos Scientific Laboratory | 19 | Subcritical Experiments | 47 |
| Idaho Chemical Processing Plant— | | Accident Simulations | 49 |
| First Excursion | 21 | Recent Directions | 49 |
| Idaho Chemical Processing Plant— | | Criticality Data | 50 |
| Second Excursion | 21 | Exercises | 51 |
| Recuplex Plant | 22 | Chapter 6: COMPUTER METHODS | |
| Wood River Junction Plant | 22 | Transport Theory | 53 |
| Windscale Works | 23 | Discrete Ordinates | 54 |
| Idaho Chemical Processing Plant— | | Monte Carlo | 55 |
| Third Excursion | 24 | Cross Sections | 57 |
| Summary of Consequences | 25 | Validation | 57 |
| General Observations | 25 | Quality Assurance | 58 |
| Criticality Accident Risk | 27 | Exercises | 60 |
| Exercises | 27 | | |

Chapter 7: SUBCRITICAL LIMITS

| | |
|--------------------------------|----|
| General Limits | 65 |
| Single-Parameter Limits | 65 |
| Aqueous Solutions | 66 |
| Metal Units | 66 |
| Multiple-Parameter Limits | 67 |
| Concentration-Dependent Limits | 67 |
| Slightly Enriched Uranium | 68 |
| Other Considerations | 69 |
| Operating Limits | 69 |
| Fissile Units | 70 |
| Arrays | 70 |
| Summary | 73 |
| Exercises | 73 |

Chapter 8: HAND CALCULATION METHODS

| | |
|---------------------------|----|
| Buckling/Shape Conversion | 75 |
| Surface Density Method | 77 |
| Density Analog Method | 78 |
| Solid Angle Method | 79 |
| Exercises | 81 |

Chapter 9: REGULATION AND RELATED IMPACTS

| | |
|----------------------------------|-----|
| U.S. Regulatory Bases | 85 |
| Nuclear Regulatory Commission | 85 |
| Code of Federal Regulations | 85 |
| Guides and Standards | 86 |
| Organization | 87 |
| Fuel Facilities Licenses | 89 |
| Post-TMI-2 Evolution | 94 |
| Department of Energy | 95 |
| Organization | 95 |
| Orders | 96 |
| Field Office Implementation | 102 |
| Safety and Safeguards Interfaces | 102 |
| Radiation Safety | 102 |
| Fire Protection | 102 |
| Nuclear Material Safeguards | 103 |
| Exercises | 105 |

Chapter 10: PRACTICES

| | |
|--------------------------------------|-----|
| Administrative Practice | 109 |
| Administrative Standards | 109 |
| Organizational Implementation | 109 |
| Quantitative Evaluation Methods | 114 |
| Design and Operation | 115 |
| Geometry Control | 116 |
| Poisons | 117 |
| Mass and Volume Limits | 118 |
| Moderation and Concentration Control | 119 |
| Storage and Transport | 119 |
| Control Specifications | 120 |
| Exercises | 122 |

Chapter 11: FUEL FACILITY APPLICATIONS

| | |
|--|-----|
| Enrichment | 127 |
| Process | 128 |
| Packaging and Shipping | 128 |
| Uranium-Oxide Fuel Fabrication | 128 |
| Fluoride-to-Oxide Conversion | 129 |
| Powder Processes | 129 |
| Fuel Assemblies | 131 |
| Reactor Handling and Storage | 131 |
| Fresh Fuel | 131 |
| Spent Fuel Storage | 132 |
| Spent Fuel Shipping | 133 |
| Reprocessing | 135 |
| Head-End Processes | 135 |
| Separations | 136 |
| Storage | 136 |
| Recycle | 137 |
| Plutonium Shipping | 137 |
| Mixed-Oxide Fabrication | 137 |
| Waste Management | 138 |
| Other Fuel Cycles | 138 |
| Heavy Water Reactors | 139 |
| Graphite-Moderated Reactors | 139 |
| Fast Breeder Reactors | 140 |
| Non-Power Reactor and Other Applications | 141 |
| Epilogue | 141 |
| Exercises | 142 |

Appendix A: MONTE CARLO APPLICATIONS

| | |
|--|-----|
| KENO Features | 145 |
| Weighting/Biasing | 145 |
| Neutron Generations and Fission Source | 145 |
| Cross Sections | 145 |
| Reflectors | 145 |
| Geometry | 145 |
| Searches | 145 |
| Computer Input and Output | 147 |
| Material Compositions | 147 |
| Number Densities | 147 |
| Constituent Percentages | 148 |
| KENO/MONK Comparison | 148 |

Appendix B: SURFACE DENSITY CALCULATION

| | |
|-------------------------------|-----|
| Storage Array Spacing Example | 154 |
| Storage Array Content Example | 155 |
| Cautions | 155 |

Appendix C: SOLID ANGLE CALCULATION

| | |
|----------------------------|-----|
| Array of Cylinders Example | 159 |
| Process Equipment Example | 161 |
| Cautions | 162 |

| | | | |
|---|----------------------------------|--|------------|
| Appendix D: LIMITING SURFACE DENSITY CALCULATION | | Internal Appraisal Checklist | 216 |
| | | DOE Audit/Appraisal Outline | 217 |
| | Method | | 163 |
| | Array Example | | 165 |
| | Storage Vault Example | | 169 |
| Appendix E: CRITICALITY ACCIDENT ALARMS | | Appendix G: TMI-2 RECOVERY OPERATIONS | |
| | Standard | Accident Overview | 219 |
| | Design Criteria | Operational Considerations | 220 |
| | Experimental Program | Accident Changes | 220 |
| | Additional Studies | Recovery Activities | 220 |
| | | Operator Training | 222 |
| Appendix F: REGULATORY DOCUMENTS | | Analysis Approach | 222 |
| | NRC License Forms | Methods and Codes | 222 |
| | NRC Safety Evaluation Report | Core Region | 223 |
| | Licensee Safety Analysis Reports | Fuel Outside of the Core | 223 |
| | NRC Inspection Checklist | Results | 224 |
| | Internal Inspection Checklist | Defueling Update | 224 |
| | | Reactor Coolant System Evaluation | 224 |
| | | Defueling System | 225 |
| | | Fuel Transport and Storage | 226 |
| | | Index | 229 |